# TagBot

Written By: DaveGun

## TOOLS:

- Electric or Hand Saw (1)
- Hack saw (1)
- Modeling knife (1)
- Pencil or pen (1)
- Punch (1)
- Scissors (1)
- Screwdriver, Phillips head (1)
- Side cutters (1)
- Soldering/desoldering tools (1)
- Square, adjustable (1)
- Standard drill bits (1)
- Tin snips (1)
- hand electric drill (1)
- mill bastard file (1)
- small pipe cutter (1)

## PARTS:

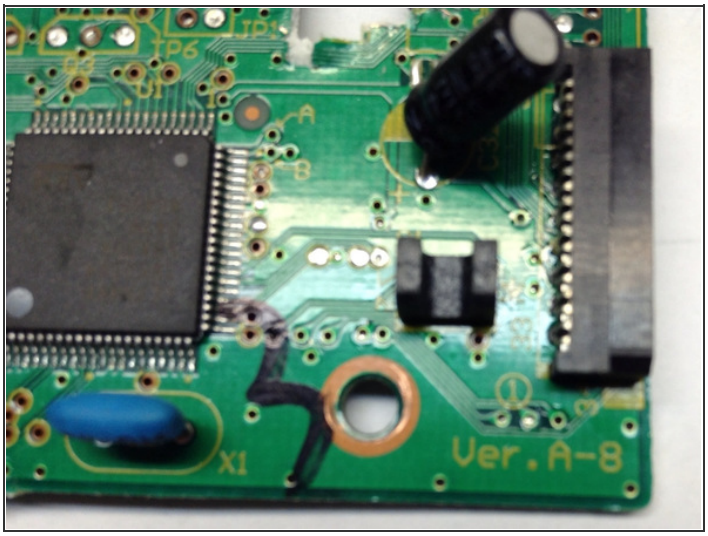
- Motor (2)
  *Salvaged from printer*
- LED/Photo Sensor (1)
  *Salvaged from printer*
- Switch, momentary (1)
  *Salvaged from printer*
- Plastic Card (1)
  *Salvaged from printer paper holder*
- Parallax PIR sensor (3)
- 1/4" plywood (1)
- Aluminum Round Tube (1)
- Aluminum square tube (1)
  *A 3 foot length will be sufficient*
- Angle brackets (9)
- Straight Brackets (2)
- wheels (4)
  *Arnold*
- Carriage bolt (2)
  *Must have long threaded shaft*
- 3/8" bolt / nuts (8)
  *Nuts for Carriage Bolts*
- Washers (2)
  *To fit on Carriage Bolt*
- Swivel Caster Wheel (1)
- Foam Core Board (1)
- Misc. small nuts, bolts, and washers (1)
  *For mounting PIRs and Arduino*
- Sheet metal screws, self-tapping (1)

- Sheet metal screws, self-tapping (1)
  *For mounting motor mounts to rail, etc.*
- Wood screws, small (1)
  *For mounting caster wheel and sensor to deck*
- Tape, masking (1)
- Adhesive tape, double-sided (1)
- Rubber bands (1)
  *Small for drive belts, wide for pulleys*
- Zip ties (4)
- Velcro tape (1)
  *For mounting batteries*
- Arduino Uno (1)
- Arduino Motor Shield (1)
- MakerShield (1)
- 8 "AA" Battery holder (1)
- Battery clip 9V (1)
- Jumper Wire (1)

## SUMMARY

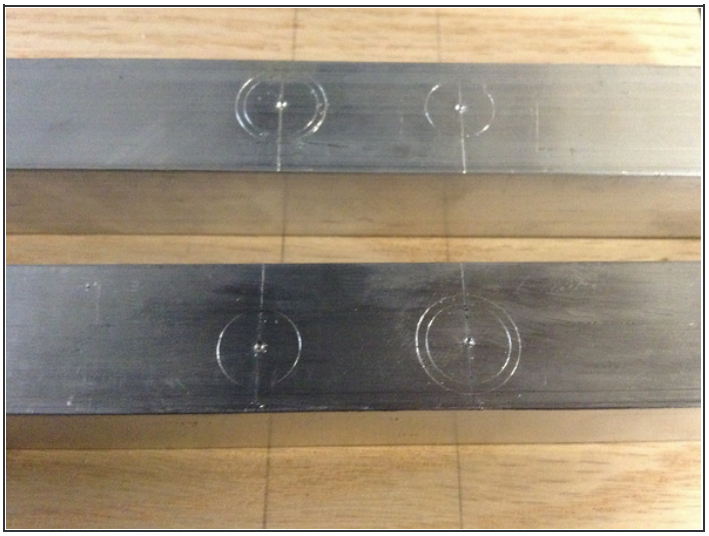
This project will show you how to build this bot from scratch. The motors, LED/photo sensor and bumper switch were salvaged from unused printers. The brains are the Arduino, attached to a Motor Shield and MakerShield. The other parts are readily available at most hardware stores.

## Step 1 — Salvage Printer Parts

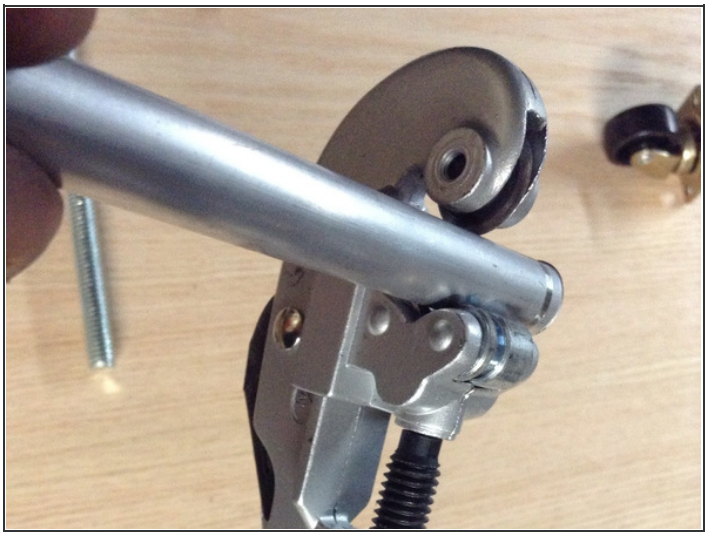

- A lot of good parts can be salvaged from old printers. For this project, the DC Motor, LED/Photo Detector Sensor and the switch with a lever will be used. The location of these parts are indicated in the picture. This project will require two DC motors, so two salvaged printers will be needed.
- Remove the two screws securing the motor, and unplug the power wire. Put the motors aside so they can be used later.
- Remove the circuit board. The switch and sensor will need to be de-soldered and removed from the board. Note the markings on the circuit board that that indicate what the pins are on the sensor. Mark the pins for future reference.
- Note the nice stepper motor also in the printer. It's not used in this project, but it's prime picking for other projects.

## Step 2 — Make the Frame

- The frame will be made of a 6½ inch wide by 8 inch long piece of plywood. Two aluminum rails will be fastened to the long edge of the plywood. This will form the deck and side rails of the frame.
- Mark the 6½” wide by 8” long rectangle on the ¼” plywood sheet. Mark 2 inches and 3 inches from one end to identify location of both axles.
- Cut two 8 inch sections of ¾” square tube for the side rails. Mark one with R and the other with L on the front top edge so you don't mix these up when working on them.
- Turn the rail so the inside edge is up. Mark two inches and three inches from the rear edge of the square tube. These will be the center line of the two axles.
- The holes in the side rails will be drilled slightly above the center of the rail. Measure down from the top side of both square tubes 5/16" and mark this with a center punch.
- Drill the forward hole on the right tube to ½”, and drill the rearward hole of the left tube to ½”. Both these holes will go through both sides of the rail.
- The remaining two holes will be 3/8" holes and these only go through the inside of the rail.

## Step 3 — Make Axles and Sleeves



- Each axle will run through a sleeve inside the side rails. To make this sleeve, use a pipe cutter to cut two ¾” sections of aluminum round tube. Insert this axle sleeve in the 1/2” hole on each rail.
- Make the axles from two 3/8” x 8” carriage bolts. Using a hack saw, cut the heads from two 3/8” x 8” carriage bolts leaving as much shaft length as possible.

## Step 4 — Ready the Deck

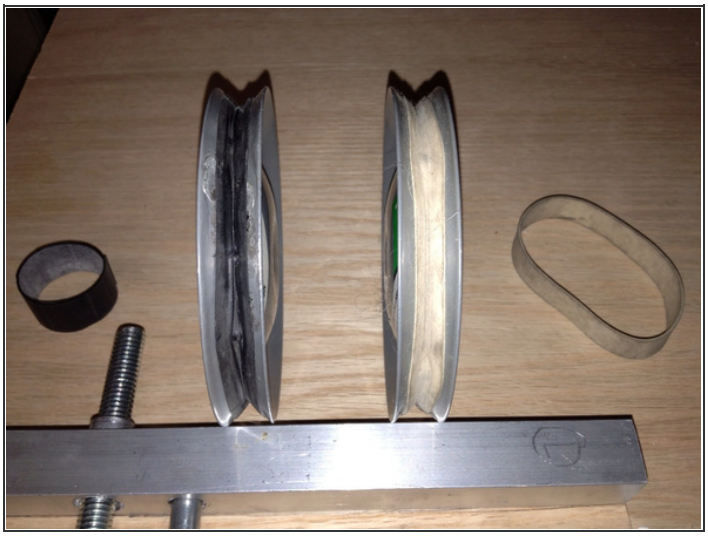

- Test fit the assembly by placing the square tube on the edges of the marked plywood rectangle and insert the axles. The axle's threaded end should go through the sleeve, and the un-threaded end into the small hole. Make sure the axles turn freely without binding.
- Cut the plywood on the marks.
- Tip: Score the marks with a knife and put tape along the edge before sawing to prevent the edges from fraying.
- Place the square tubes on the edges of the board, clamp them in place and drill two pilot holes just slightly smaller then the attachment screws. Using 4 sheet metal screws, attach the square pipe to the board near the edges of the board making sure these screws do not interfere with the axles.

## Step 5 — Make the Axle Location Ring



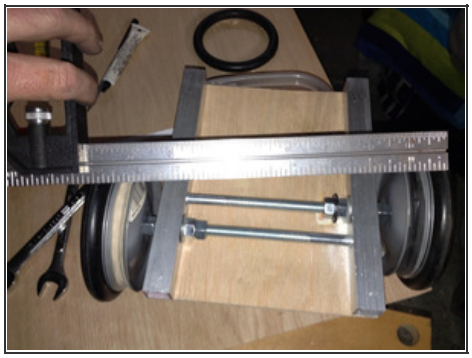
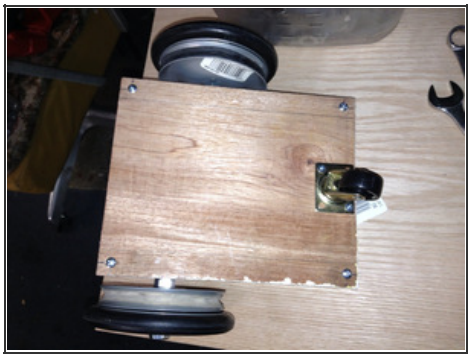
- The wheel location sensor uses a stationary photo eye and a slotted washer fixed to the axle. The photo eye will count the number of slots that pass the sensor. We will call this slotted washer the “axle location ring.”
- The axle location ring is made by using a flat piece of plastic, such as the one from the paper tray of the salvaged printer. Drill a 3/8” hole in the plastic. Using a 7/8” washer as a template, center the washer on the hole and mark the outside edge of the washer. Use tin snips to cut out the plastic washer.
- Six evenly spaced 1/8” slots need to be cut in the outside edge. To space these equally, use a large hex nut as a guide. Center the nut on the plastic washer and mark the points of the nut onto the washer.
- Using a hacksaw, cut six slots in the edge of the plastic washer.
- Hint: Clamp a straight-edged piece of metal through the center point of the washer and use this straight edge as a guide for cutting the slots. Put a mark 1/8 of an inch up from the cutting edge of the hacksaw blade as a depth guide to make all cuts to the same depth.

## Step 6 — Prepare the Wheels and Pulleys



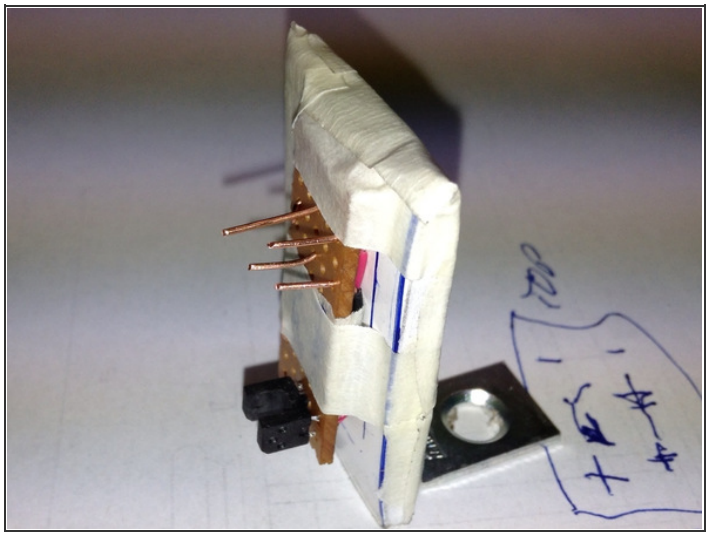
- Remove the rubber from two of the 4.5” wheels. These two rims will be used for drive pulleys.
- Use a fat rubber band and stretch it over the rim to provide a surface for the belt to ride inside the pulley. I also used a section of bicycle inner tube, but it is much harder to stretch over the rim.

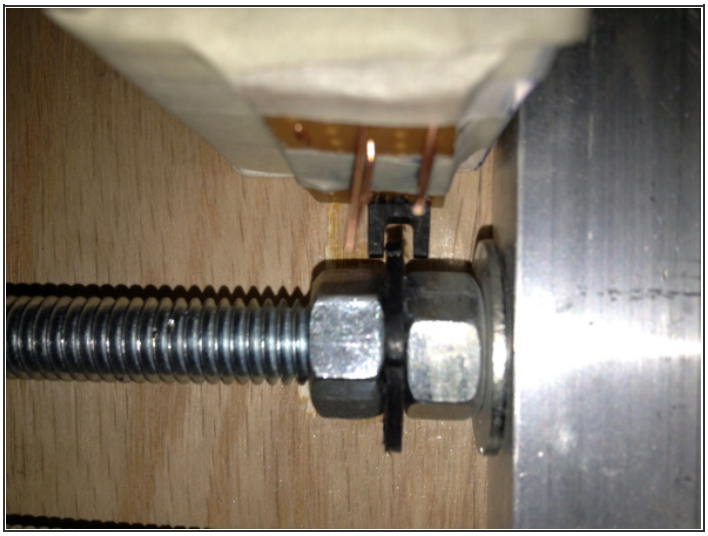
## Step 7 — Assemble the Wheels and Axle

- Now it's time to assemble the wheels and axle. Start with the left wheel in the rear hole on the left rail. Thread two nuts onto the axle then a metal washer. Run the threaded end of the axle from the inside through the sleeve.
- Thread another nut on the axle, then put on one drive pulley, one wheel, then finally a nut. Tighten the wheel and pulley between the two outside nuts just snug enough so the wheel and pulley are fixed together.
- Place the end of the axle into the smaller rear hole in the right rail. Thread the inside two nuts up against the sleeve then back them off to allow a little play so the axle and wheel spins freely. Tighten the inside two nuts together to form a lock nut. Re-adjust the play if necessary.
- Hint: you can use plumber's Teflon tape and or Teflon lubricant on the axle in the sleeve to proved a little dry lubrication. You will need to test fit the wheels and axle first. Mark the part of the axle that rides inside the sleeve, then disassemble the assembly to expose the part of the axle that receives the lubricant.
- Do the same procedure for the right wheel in the forward sleeve on the right rail with one additional step. The axle location ring (plastic washer with slots) needs to be placed between the two nuts on the inside of the axle.
- The plywood below the axle location ring may need to be ground down a little to allow the axle location ring to spin freely. This can be done with a small file, or small wood chisel.
- The last thing is to attach the caster wheel on the front underside of the plywood with short wood screws. Center the wheel and mark the holes. Drill a pilot hole that is slightly smaller than the wood screw threads. Secure the caster wheel with the screws.

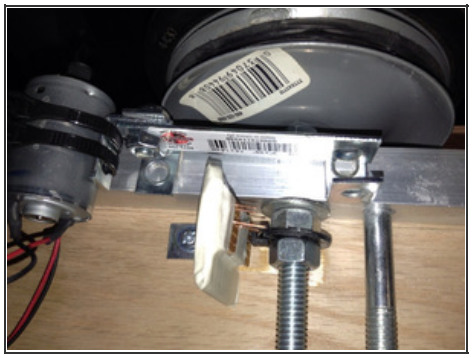
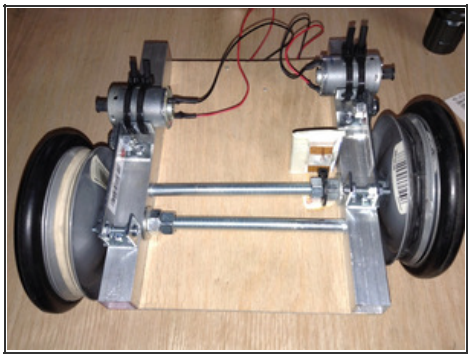
## Step 8 — Make the Axle Position Sensor





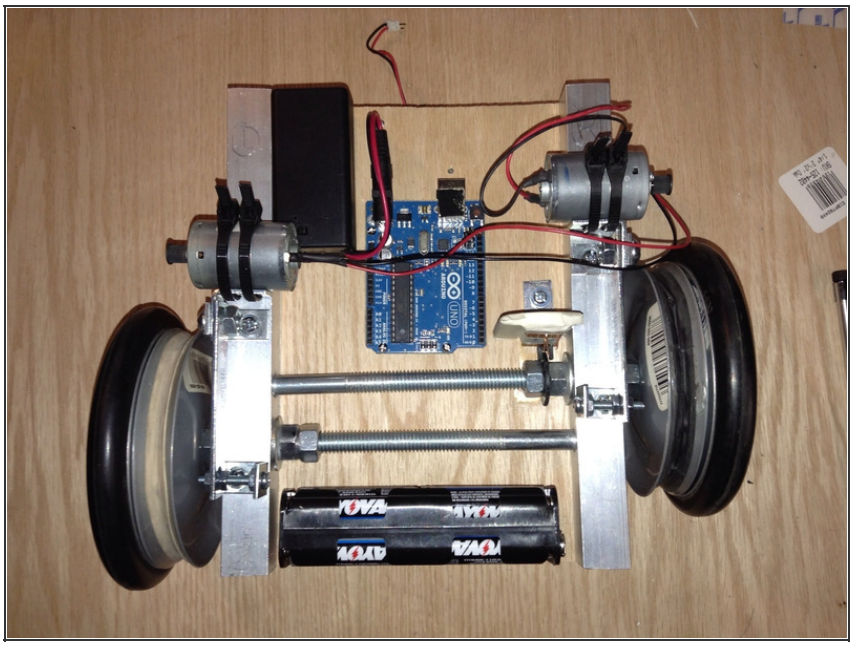
- It is important for the distance from center to center of the wheels to be approximately 9 inches, and twice the diameter of the wheels. One rotation of counter-rotating wheels will then turn the bot 180 degrees. The axle location sensor will be used to spin the bot to the desired direction.
- The LED/ Photo Sensor salvaged from the printer needs to be mounted on a small board. Cut a small piece of circuit board. Solder wire leads on the four terminals and extend the four leads out of the holes in the circuit board.
- Tape the sensor to a small piece of foam board, then tape a small angle bracket on the back of the foam board. Mark the four leads for connection later in the project.
- The axle location ring will spin inside the slot in the sensor. Test fit the sensor in front of the forward axle. The axle location ring must be in the slot as far as possible without rubbing on the sides or back of the sensor slot when the wheel spins.
- The play in the axle may need to be reduced by readjusting the inside nuts on the axle. When the sensor is located correctly, mark the hole in the mounting angle bracket. Drill a small pilot hole in the deck and attach the sensor with a wood screw.

## Step 9 — Assemble the Motor Mounts

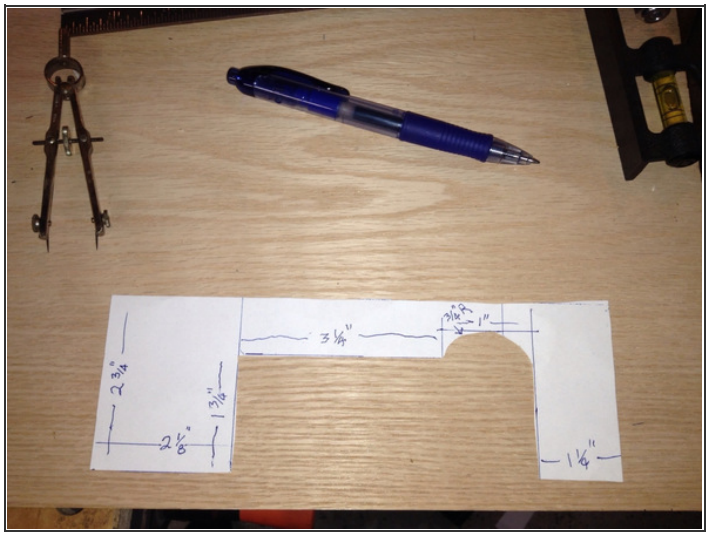
- Now the right motor mount can be assembled. Attach a motor to a small angle bracket with two zip ties. Attach the angle bracket to a second angle bracket and a 3” metal straight bracket as shown in the picture. This straight bracket will be used to adjust the motor so the belt stays aligned.
- Place the motor assembly on the right rail in front of the wheel as shown in the picture. Place a third angle at the open end of the metal strap in line with the last hole. Align the hole of the angle between both axles so the attachment screw will not interfere with the axles.
- Mark the holes of the two angles and center-punch the mark. Drill pilot holes and attach the motor mount with sheet metal screws.
- Do the same for the left wheel motor. The rear angle bracket will be behind the rear axle so the distance from the pulley to the motor will be the same for both motors. Insert a bolt with three nuts in the rear angle bracket to the straight bracket as shown in the picture. This bolt will be used to align the motors.
- The drive belts are rubber bands. Stretch the rubber bands over the pulley and motor shaft. Move the wheel by hand forward and backwards to check the alignment of the belt. Line up the motor shaft as close as possible by eye.
- The motor can be slid in and out so that the shaft is in line with the pulley. Small adjustments can be made by moving the nuts on the adjustment arm. Once the belt stays on the motor when the wheel is moved in both directions, the mounts and adjusters can be tightened.
- Hint: if you're having problems aligning the belt you can try pushing up and down on the motor shaft to help align the motor.

## Step 10 — Install Arduino and Batteries.



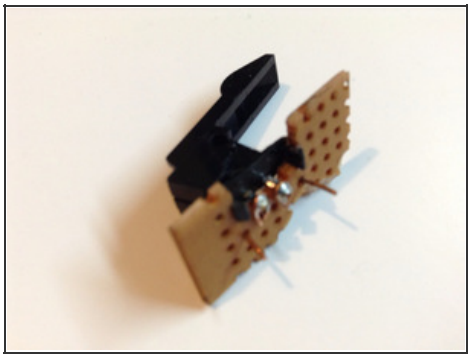
- A 12V battery pack is being used to power the motors, and a 9V is used to power the Arduino. Test fit the components on the deck.
- Mark the mounting holes of the Arduino to the plywood deck. Drill holes and, using small screws, attach the board.
- I use rubber feet stuck on the bottom of the board. If you don't have these, standoffs should be used to mount the Arduino board so that the bottom of the board is not in contact with the wood deck.
- Adhesive-backed Velcro can be used to secure the battery boxes in place so they can be removed to change the batteries.

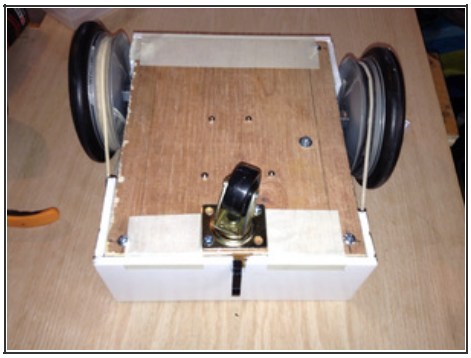
## Step 11 — Build the Body




- Make a right side panel by first using a paper template. Test fit the template to assure that it fits properly. The picture shows my template and the dimensions I used. It is 2¾" tall overall. There is a cutout for the wheel and motor.
- Once this fits correctly, transfer the template to a piece of foam board. The bottom of the foam board can be attached to the square tube with sheet metal screws.
- The left side panel should have the same cutout, except it will be shifted one inch back. You can use the same template modified for the one-inch shift.
- You may not have room to use a screw on the rear of the foam board side. An alternate means of attachment can be used, like masking tape.
- The rear panel is straightforward. Attach it at the sides and bottom edge with masking tape.
- The front panel will be the attachment for the bumper and bumper switch. First you will need to prepare the switch.

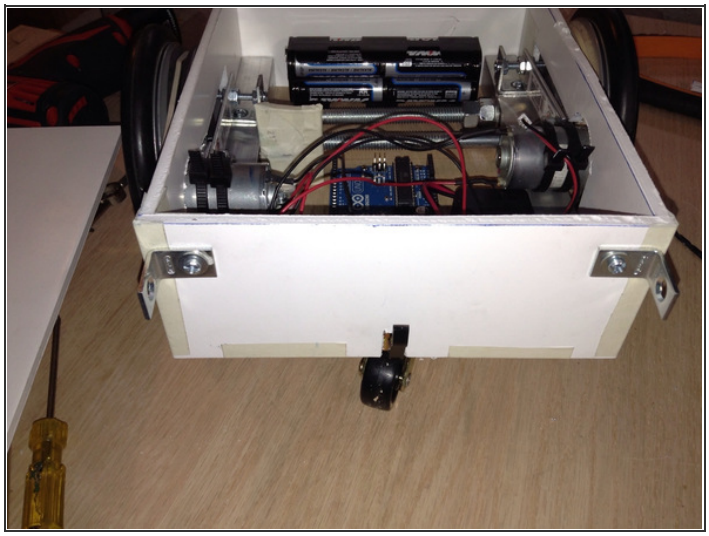
## Step 12 — More Body Parts





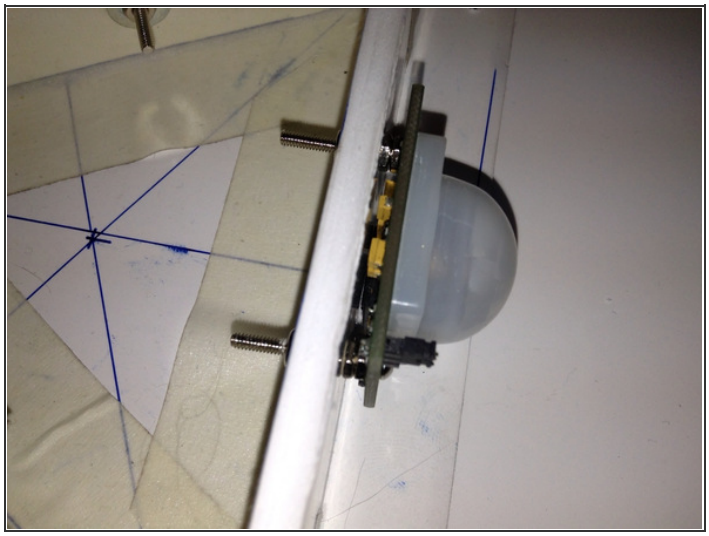
- The switch has a long paddle and works well for a bumper switch. It was salvaged from the circuit board of the printer. Mount the switch to a small piece of circuit board. Solder some lead wires and route these so they exit the rear of the switch as shown in the picture. The wire leads will need to be accessible from inside the body.
- Test fit the front panel and mark the top edge of the plywood floor on the panel. One important step not shown in this picture: locate the spot in this front panel that is in line with the USB port on the Arduino board. Cut a small hole to allow connection of the USB cable.
- Next, cut another notch in the bottom of the front panel so the switch lever can come through the front panel. Tape the switch in place from the inside of the panel.
- Measure and cut the top out of the foam board. Cut four small squares that will keep the top in place. Attach the squares with double-sided sticky tape. Do not fasten the top on the body; this will need to be removed for access.

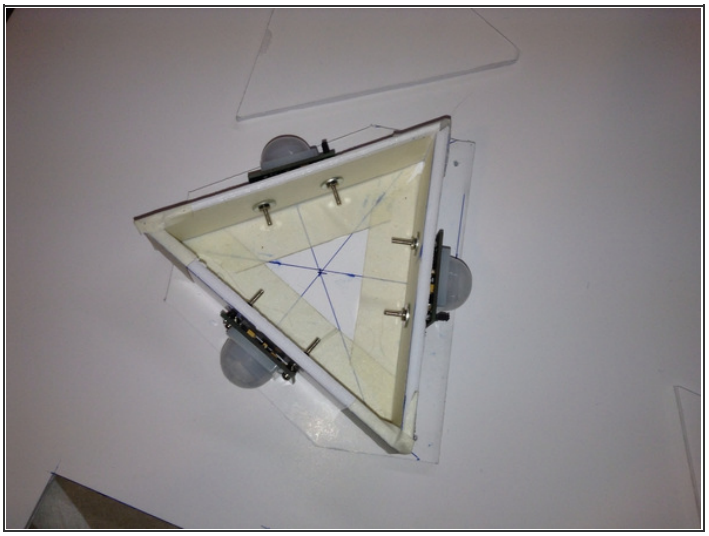
## Step 13 — Make the Bumper



- Attach two small angle brackets to the front panel as shown in the picture. The brackets are attached with small screws, nuts and washers.
- Cut a piece of foam board that will fit inside the angles and hang about an inch below the plywood deck. Hinge the bumper on the angles with two pins (small nails) in the sides of the foam board so the bumper moves forward and back freely.
- The bumper can be lifted and tipped back against the body to gain access to the USB hole (not shown in this picture). When the bumper is pushed in, it should depress the switch. Tape a small square of foam board on the back of the bumper that aligns with the switch lever to assure the switch will be fully depressed when the bumper is pushed in.

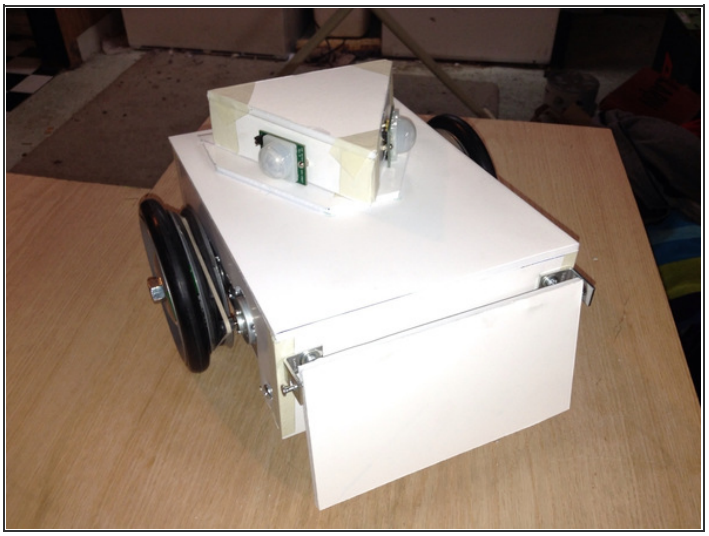
## Step 14 — Make PIR Sensor Array





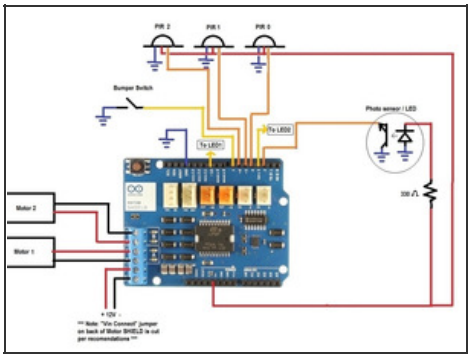
- Cut three strips of foam board 5 inches long and 1¼ inch high. Tape these together to form a triangle with corners of approximately 60 degrees.
- Mount three PIRs with the pins down, one in the center of each side of the triangle. PIRs can be mounted with small screws and nuts. Two nuts between the PIR and foam board make a good standoff for the PIR circuit board.
- Mount the triangle to a larger foam board base. Cut out access holes in the foam base to the connection pins of the PIRs so they can be wired from inside the body of the bot.
- Hint: With a marker, write the pin function (GND, 5V, Output) on the bottom of the foam base for connection of wiring at a later time.

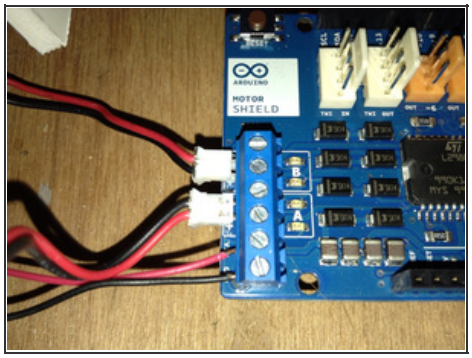
## Step 15 — Mount PIR Array to Body

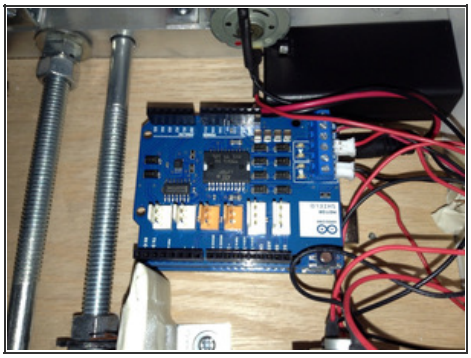


- Position the PIR sensor array on the top body panel with the center of the array approximately centered between the wheels. Make cut outs in the top panel for access to the PIR pins.
- Fasten the array with two small bolts, washers and nuts.
- Finish off the array by cutting and fastening a foam board triangular top.

## Step 16 — Wire the Motor Shield

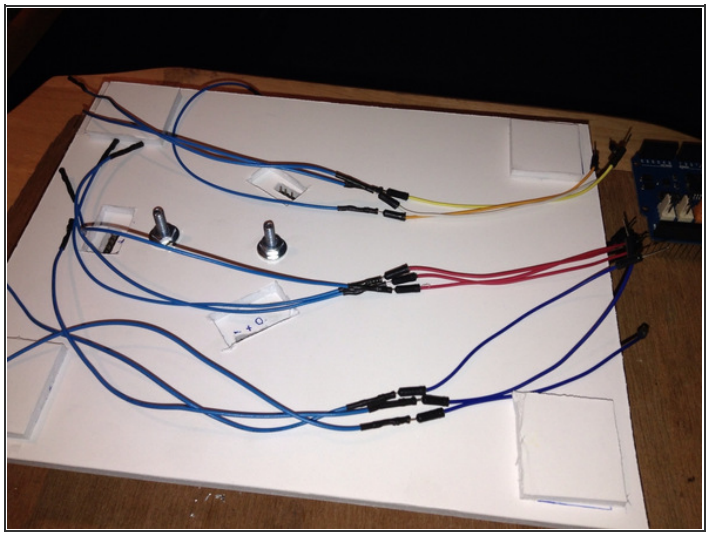


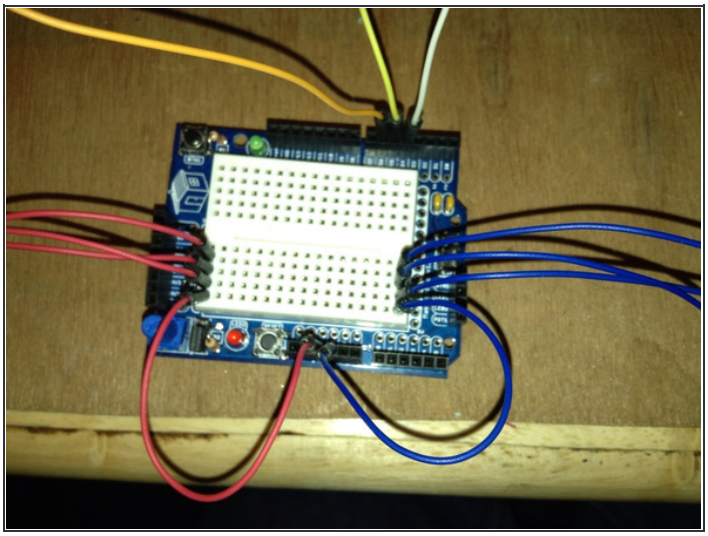


- Note: The Arduino Web Page suggests cutting the "$V_{in}$ Connect" jumper on the back of the motor shield board when using more than 9 volts. Refer to the Arduino web site for more information.
- Attach the 12V positive lead (red) to the $V_{in}$ screw terminal of the motor shield. Attach the 12V negative lead (black) to the GND screw terminal.
- The right side motor is attached to the Channel A screw terminals, red to "+" and black to "-". The left side motor runs reversed, so connect this to the Channel B screw terminals also reversed with the black wire to the "+" and the red wire to the "-".
- Insert the motor shield on top of the Arduino board.

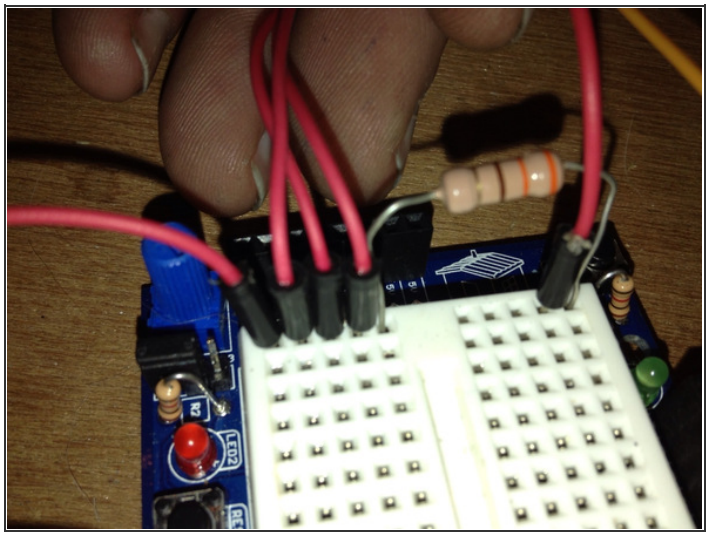
## Step 17 — Wire the MakerShield: Sensor Array

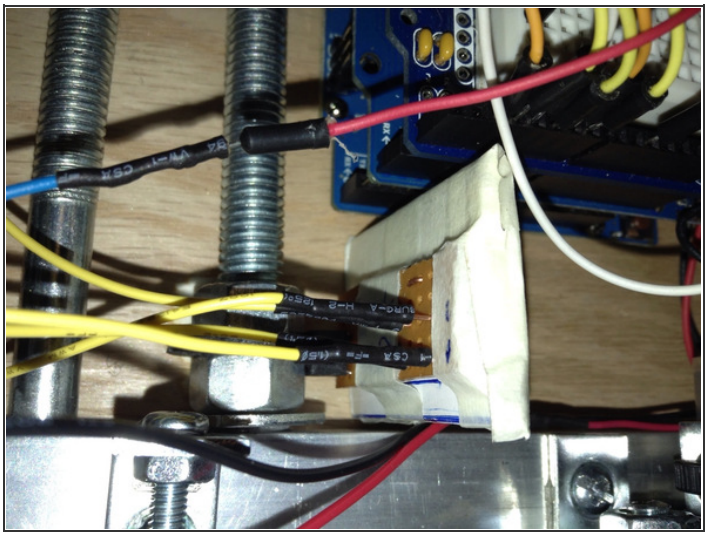




- Using male/male and female/female leads, make up three sets of power, ground, and sensor output wires. Attach the leads to the sensors.
- In the photos, the red leads are power, the blue are ground, and the other colors are sensor leads. The female/female leads are yellow or blue, so the color of the male/male lead attached to one end indicates the wire's function. This is typical throughout the photos.
- Connect a row on the breadboard to ground and another row to 5V. Connect all the PIR power leads to the 5V row, and all the grounds to the ground row.
- The PIR input pins are 4, 5, and 6. Pin 4 goes to the left PIR sensor, pin 5 to the right sensor, and pin 6 to the rear sensor.
- The two LEDs built into the board can be connected by running a jumper from LED1 to Pin 10, and LED to Pin 3.
- Tip: These LEDs can be used in testing. Place TagBot on a small box so the wheels are off the ground so it can be tested on a table. This will be useful when the USB cable is connected.

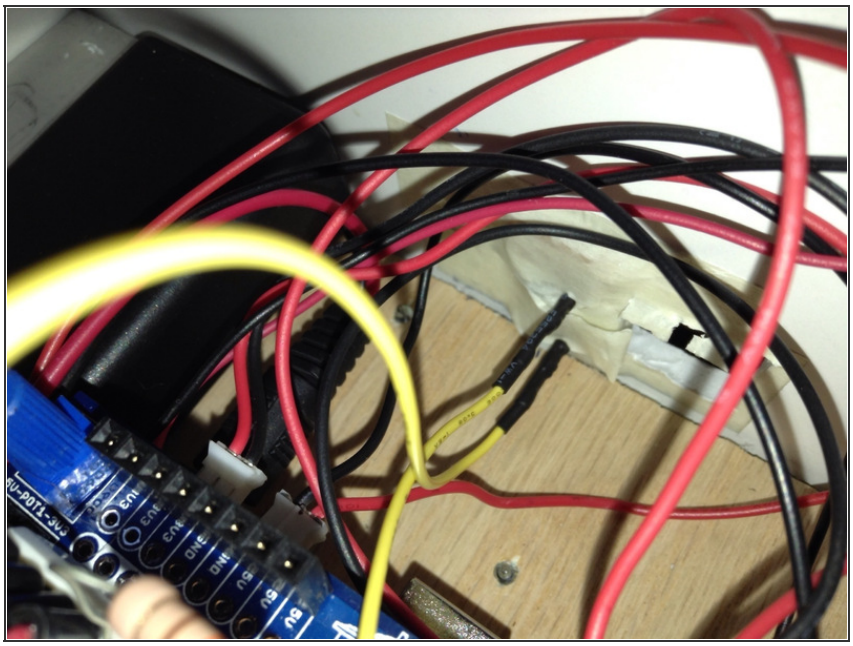
## Step 18 — Wire the MakerShield: Axle Position Sensor:





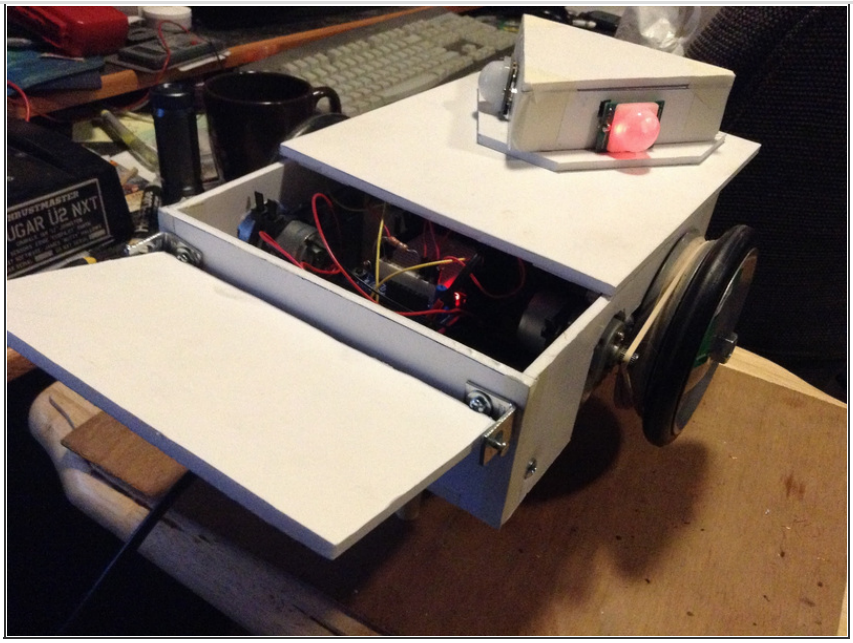
- On the 5V row on the breadboard, put a 330 ohm resistor and extend it to another open row.
- Connect a lead from this to the LED of the sensor.
- Put a jumper from the ground row to another open row, connect two ground leads to the sensor LED and photo sensor.
- Connect the output of the photo sensor to Pin 2.

## Step 19 — Wire the Bumper Switch



- Connect one lead from the bumper switch to pin 7 and the other lead from the switch to the ground row on the breadboard.
- Plug the MakerShield into the top of the Motor Shield.

## Step 20 — Testing and Adjustment.



- Lift the bumper to gain access to the USB hole. Insert the USB plug into the Arduino board and load the sketch.
- The sketch can be downloaded here.
- Start Delay: If you want TagBot to wait longer than 10 seconds after starting, the variable `startDelay` can be increased from 10000 milliseconds to a higher value.
- Stable Delay: If TagBot moves randomly after each move, you can increase the variable `stableDelay` from 500 milliseconds to a higher value. If you do this, TagBot will take longer between movements so try to keep this value as low as possible.
- Detect Delay: This allows time for a second PIR detection. The PIR array needs time to detect motion from multiple sensors for the zones between the PIRs. If you change this delay, make only small changes.
- Stuck Wheel: If the right wheel becomes stuck or the drive belt breaks, the movement will stop after 5 seconds. The value `stuckwheel` shouldn't need adjustment.
- PIR Long Light: If the PIR takes longer than about 3 seconds to turn off, it may just need more time to

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| | stabilize, or it's detecting movement. To decrease time between movements, decrease the value of `longlight`. To decrease false detections, increase this timer value. |

Now it's time to turn TagBot loose in the house. Have fun!

Dave

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